

THREDDS and the THREDDS Data Server (TDS)

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Slides by Ethan Davis - Unidata

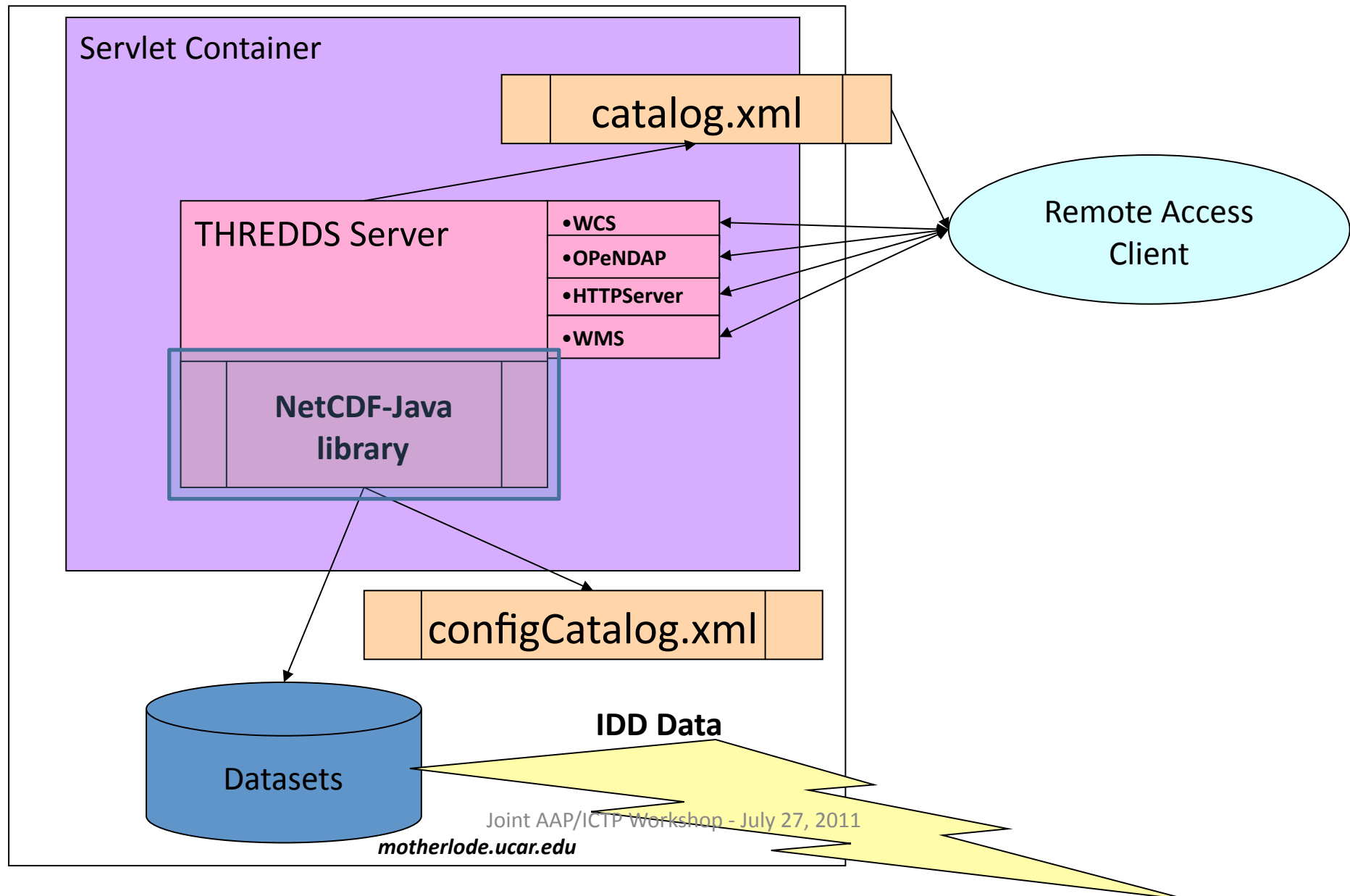
THREDDS Data Server (TDS)

- Web server for scientific data (written in 100% Java)
- Can serve any dataset the netCDF-Java library can read
 - E.g., netCDF-3, netCDF-4, HDF-4, HDF-5, HDF-EOS, GRIB-1, GRIB-2
- Catalogs advertise available datasets and services
- Data access (subset) services:
 - OPeNDAP
 - OGC WMS and WCS
 - NCSS
- Data collection services
 - Aggregation
 - Point/station collection
- Metadata services
 - THREDDS
 - ncISO: ISO, UDDC, NcML

THREDDS Data Server (cont.)

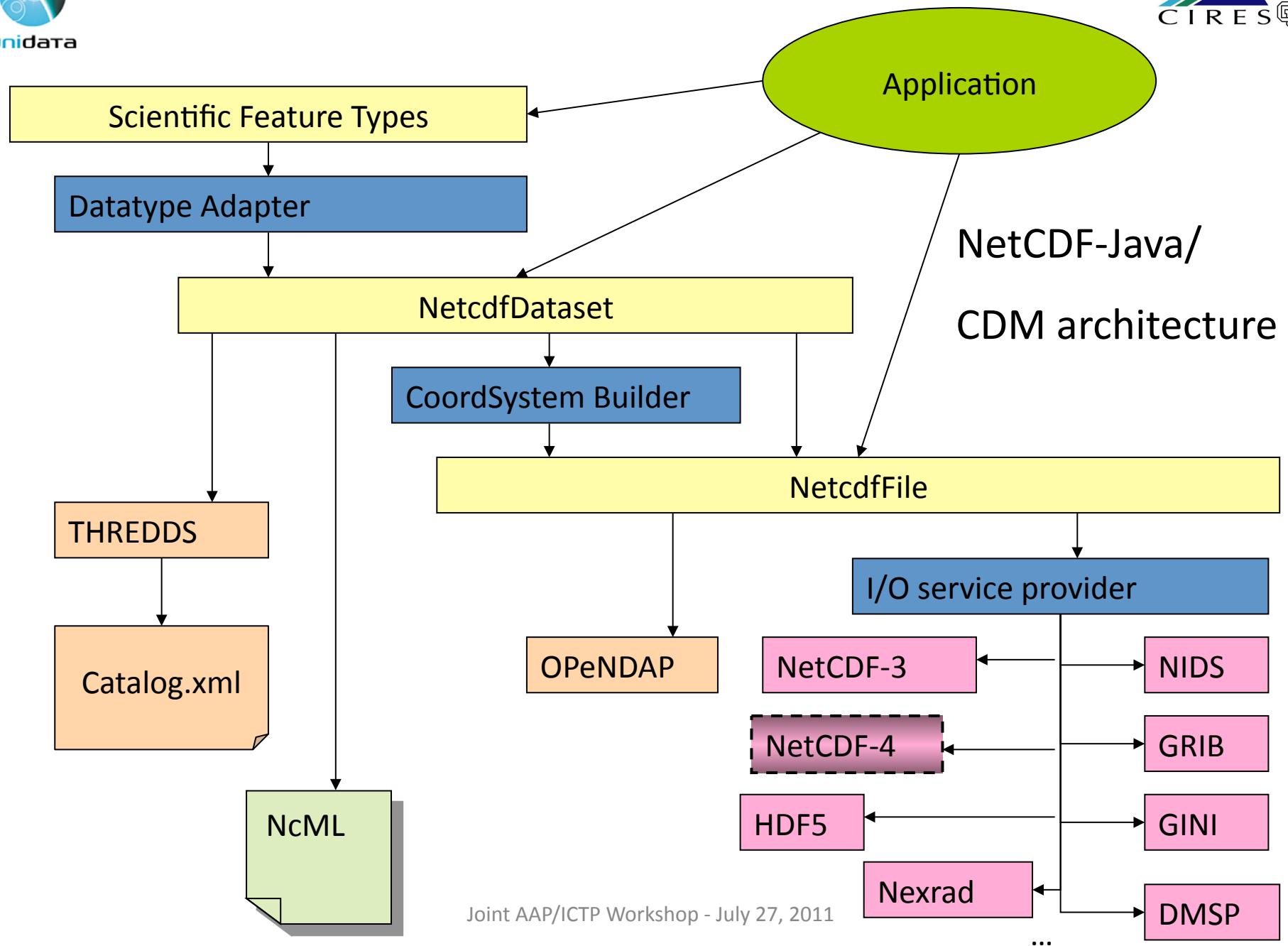
- 100% Java
- Java 1.6
 - JDK 1.7 is coming “early 2011” : new File API
- Tomcat 6.0
 - Reports that Jetty works
- Spring 2.5
 - Internal configuration
 - Spring MVC
- Packaged as a single file: **thredds.war**
- Open-source license

THREDDS Data Server

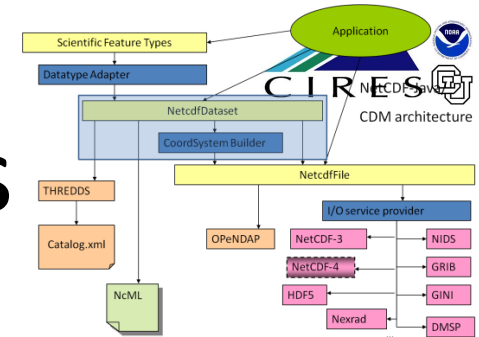


Common Data Model (CDM)

- Implemented in the netCDF-Java library (3 layers)
- NetCDF Data Access:
 - Access to array-based scientific data (netCDF data model)
 - Read various file formats, map into data model (IOSP)
- NetcdfDataset:
 - Geospatial coordinate systems (conventions)
 - NcML: Modify existing dataset
 - Aggregation of datasets
- Scientific Feature Types, e.g.:
 - Gridded Data; Radial Data; Swath Data
 - Discrete Sampling Features:
 - Point Data; Station Data; Profile Data
 - Trajectory (e.g., aircraft track) Data

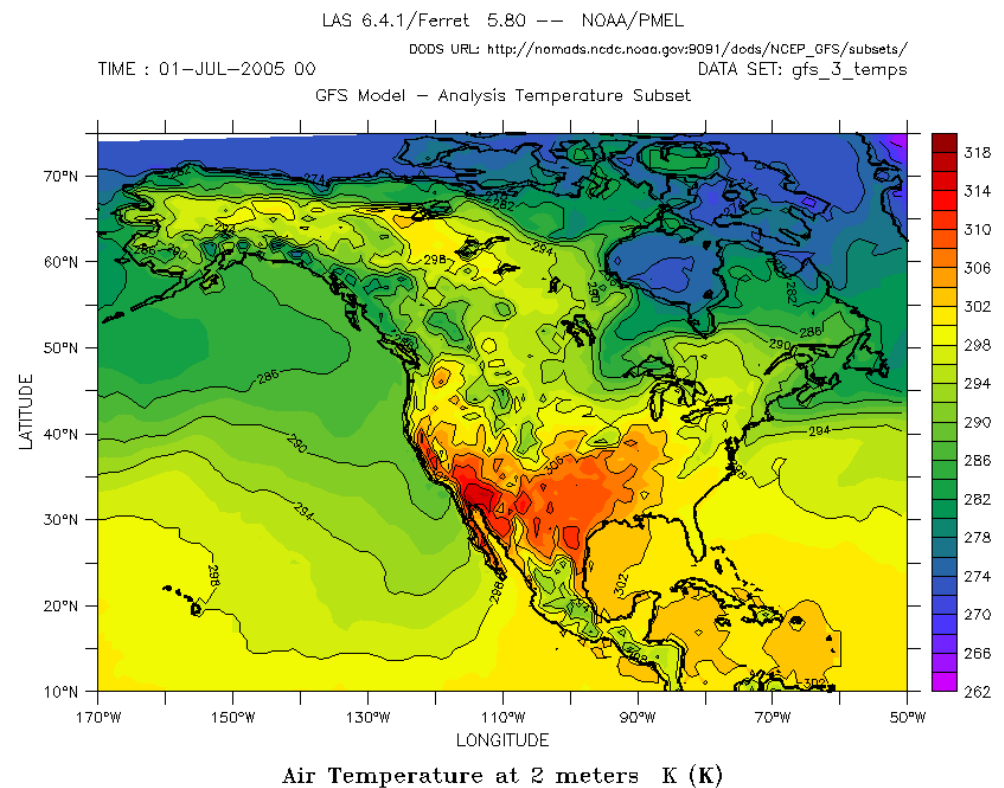
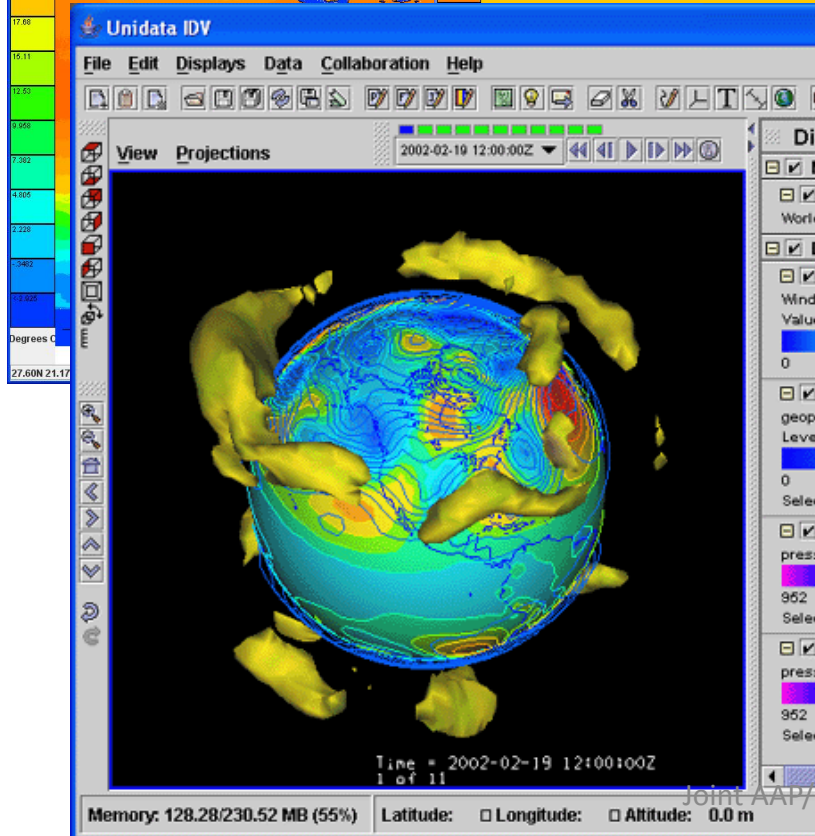
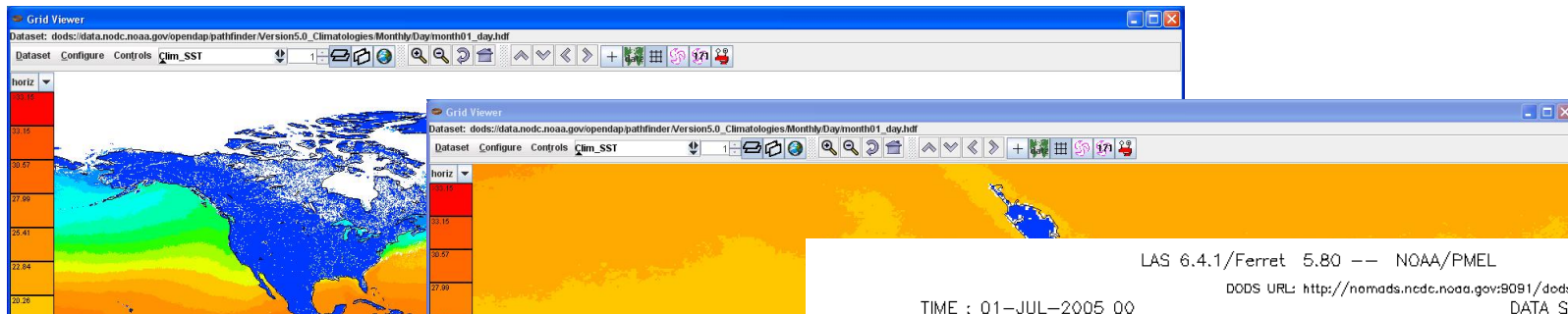


Coordinate Systems



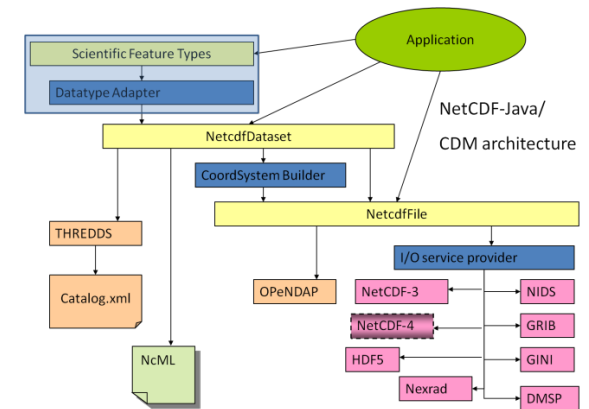
- Used to geolocate data
- Dataset must describe the coordinate systems used
- Use conventions to describe coordinate systems
 - CF Convention (recommended)
 - Other conventions are recognized by netCDF-Java library
- What you get if your data follows conventions
 - Standard visualization, debugging, and data manipulation tools
 - Standard servers to make your data remotely accessible

Coordinate Systems



Scientific Feature Types

- Gridded Data
- Radial Data
- Swath Data
- Discrete Sampling Features
 - Point data
 - Station data
 - Profile data
 - Trajectory (i.e., aircraft track) data

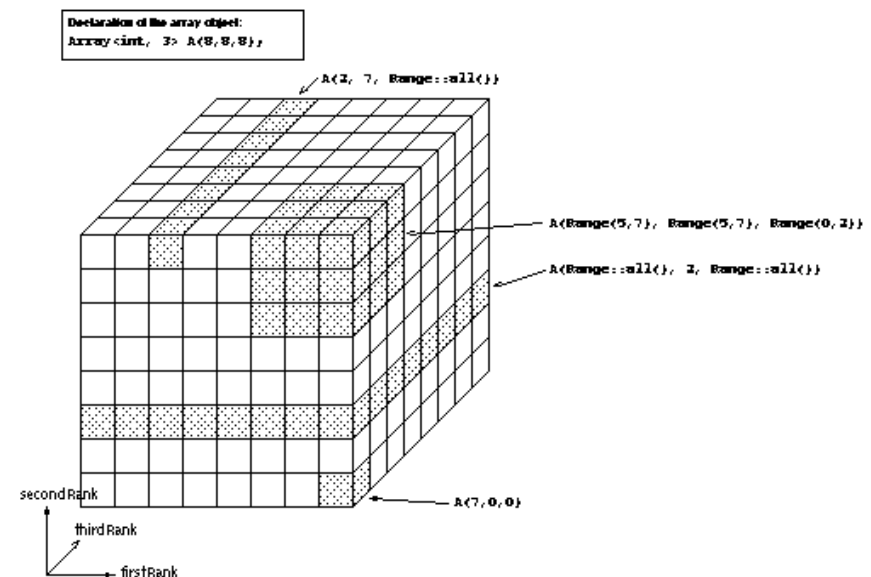


Gridded Data

- Cartesian coordinates
- Data is 2,3,4D
- All dimensions have 1D coordinate variables (separable)

```
float gridData(t,z,y,x);
float t(t);
float y(y);
float x(x);
float z(z);
```

- netCDF: coordinate variables
- OPeNDAP: grid map variables
- HDF: dimension scales



Swath

- two dimensional
- track and cross-track
- not separate time dimension
- aka *curvilinear coordinates*

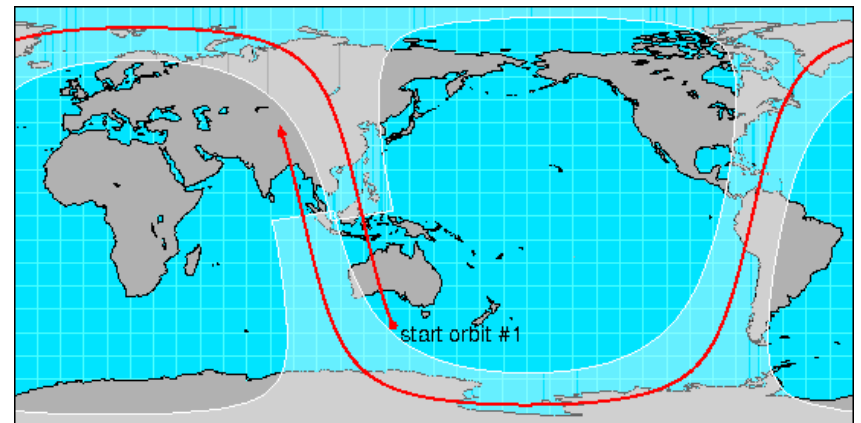
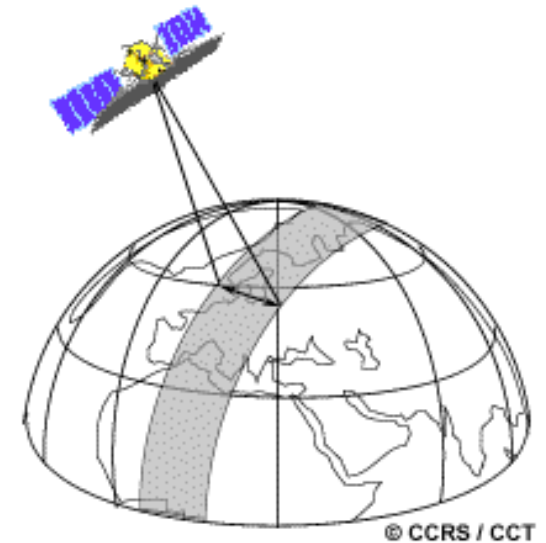
float swathData(track, xtrack)

float lat(track, xtrack)

float lon(track, xtrack)

float alt(track, xtrack)

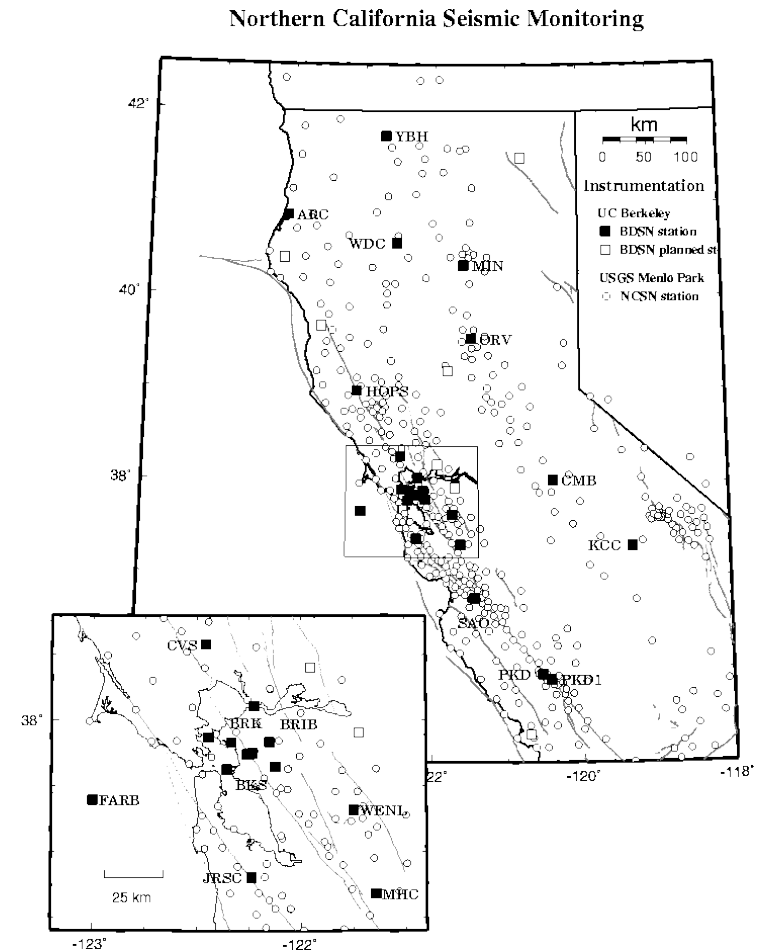
float time(track)



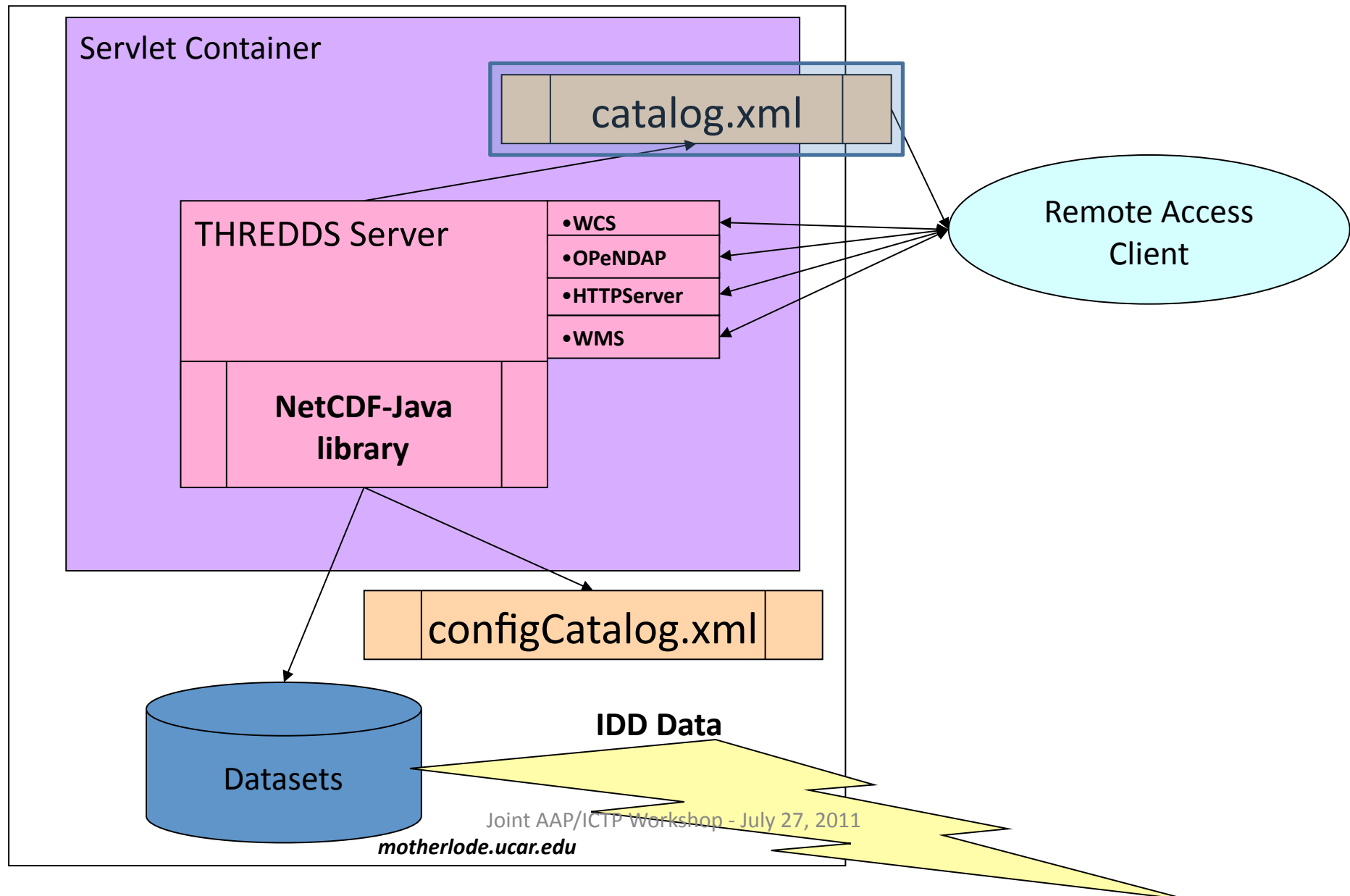
Point Observation Data

- Set of measurements at the same point in space and time = obs
- Collection of obs = dataset
- Sample dimension not connected

```
float obs1(sample);
float obs2(sample);
float lat(sample);
float lon(sample);
float z(sample);
float time(sample);
```



THREDDS Data Server



THREDDS Catalogs

- Catalogs collect, organize, and describe datasets
 - Hierarchical collections of datasets (virtual directories)
 - Each dataset may have multiple access methods
 - Documentation (metadata) may be added
 - To the catalog itself
 - To individual datasets (inheritance optional)
- Servers can use catalogs to advertise the datasets they serve

THREDDS Catalogs

```
<?xml version='1.0' encoding='UTF-8'?>
<catalog xmlns="http://www.unidata.ucar.edu/namespaces/thredds/InvCatalog/v.0"
  xmlns:xlink="http://www.w3.org/1999/xlink" version="1.0.2">
  <service name="odap" serviceType="OPENDAP" base="/thredds/dodsC/" />
  <dataset name="TDS Tutorial: example 2">
    <metadata inherited="true">
      <serviceName>odap</serviceName>
    </metadata>
    <dataset name="TDS Tutorial: example data 1" urlPath="test/example1.nc" />
    <dataset name="TDS Tutorial: example data 2" urlPath="test/example2.nc" />
    <dataset name="TDS Tutorial: example data 3" urlPath="test/example3.nc" />
    <catalogRef xlink:title="My Other Catalog"
      xlink:href="myOtherCatalog.xml" />
    <catalogRef xlink:title="Far Away Univ catalog"
      xlink:href="http://www.farAwayU.edu/thredds/catalog.xml" />
  </dataset>
</catalog>
```

THREDDS Catalogs

Catalog <http://motherlode.ucar.edu:8080/thredds/catalog.html> - Mozilla Firefox

File Edit View History Bookmarks Tools Help

[http://motherlode.ucar.edu:8080/thredds/catalog.html](#) Google

Getting Started Most Visited UCAR/Unidata TDS Javadoc WebStart Weather RTD Gantt.com Stu Holloway (Relevan... dk DexPhone

Disable Cookies CSS Forms Images Information Miscellaneous Outline Resize Tools View Source Options

Catalog <http://motherlode.ucar.edu:8080/thredds/catalog.html>

Catalog <http://motherlode.ucar.edu:8080/thredds/catalog.html>

Dataset	Size	Last Modified
Realtime data from IDD		--
NCEP Model Data/		--
Radar Data/		--
Station Data/		--
Satellite Data/		--
Other Unidata Data		--
Unidata Real-time Regional Model/		--
Unidata GALEON Experimental Web Coverage Service (WCS) datasets/		--

[Motherlode TDS at Unidata](#)

THREDDS Data Server [Version 4.2.20101024.2131 - 20101024.2131] [Documentation](#)

Done Joint AAP/ICTP Workshop - July 27, 2011 YSlow WMS

THREDDS Catalogs

Catalog Services - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://motherlode.ucar.edu:8080/thredds/catalog/fmrc/NCEP/GFS/Global_0p5deg/catalog.html?da

Catalog Services

Motherlode TDS

THREDDS Data Server

Catalog http://motherlode.ucar.edu:8080/thredds/catalog/fmrc/NCEP/GFS/Global_0p5deg/catalog.html

Dataset: NCEP-GFS-Global_0p5deg/Best Time Series

- *Data format:* GRIB-2
- *Data type:* GRID
- *Naming Authority:* edu.ucar.unidata
- *ID:* fmrc/NCEP/GFS/Global_0p5deg/NCEP-GFS-Global_0p5deg_best.ncd

Documentation:

- **summary:** Best time series, taking the data from the most recent run available.
- **summary:** NCEP GFS Model : AWIPS 230 (G) Grid. Global Lat/Lon grid. Model runs are made at 0, 6, 12, and 18Z, with analysis and forecasts every 3 hours from 96 to 180 hours (4 to 7.5 days). Horizontal= 361 by 720 points, resolution 0.5 degree, Lat/Lon projection. Vertical= 1000 to 100 hPa mandatory pressure levels (10 levels); surface, height above ground, pressure layers.
- **summary:** NCEP Global Forecast System Model, previously called AVN/MRF (Medium Range Forecast)
- [COMET MetEd \(Meteorology Education and Training\) documentation](#)
- [NCEP Model Notes](#)
- [NCEP Model documentation](#)
- **rights:** Freely available
- **processing_level:** Transmitted through Unidata Internet Data Distribution.
- **processing_level:** Read by CDM Forecast Model Run Collection.
- [NCEP/NWS Model Analyses and Forecasts Page](#)

Access:

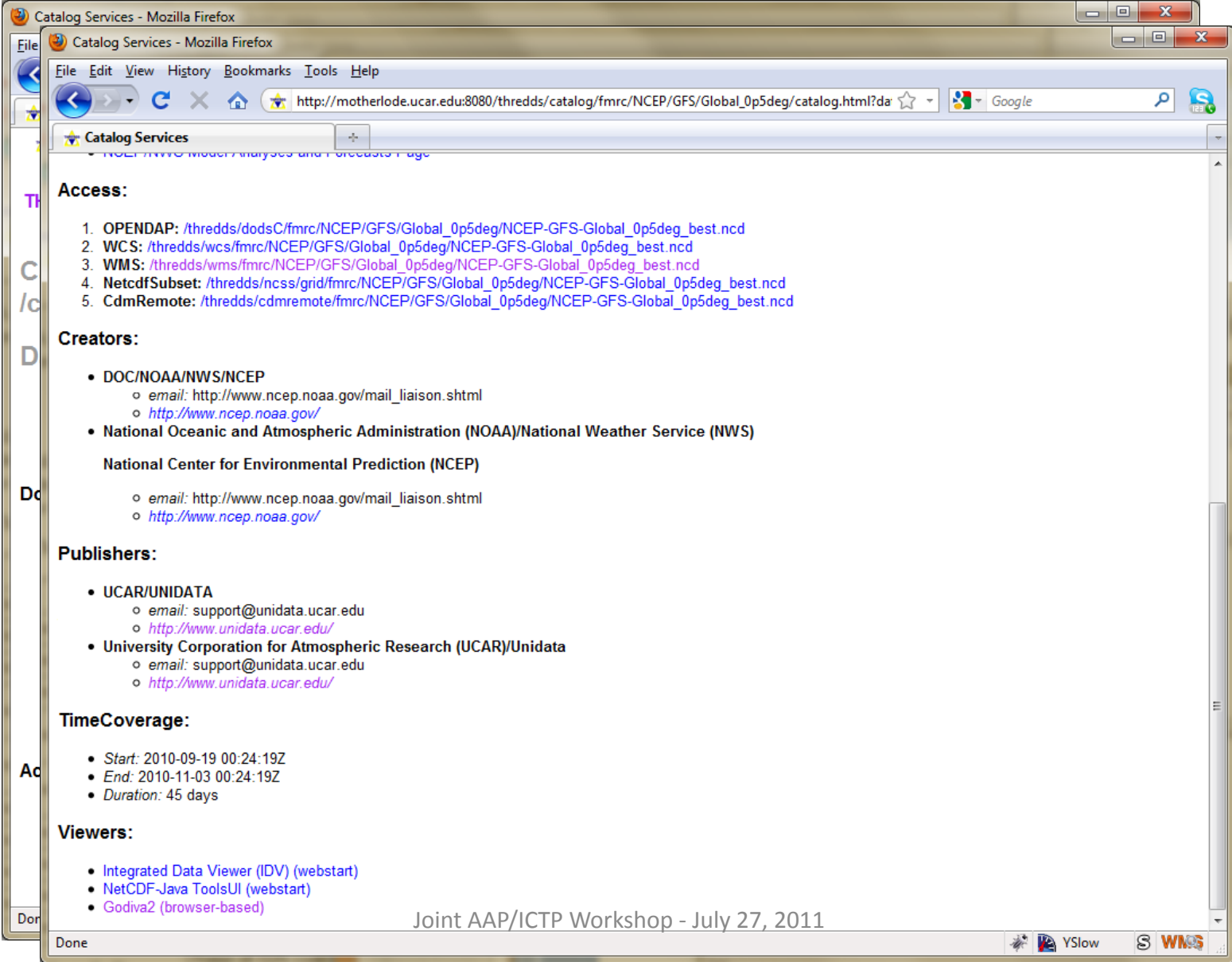
1. **OPENDAP:** /thredds/dodsC/fmrc/NCEP/GFS/Global_0p5deg/NCEP-GFS-Global_0p5deg_best.ncd
2. **WCS:** /thredds/wcs/fmrc/NCEP/GFS/Global_0p5deg/NCEP-GFS-Global_0p5deg_best.ncd
3. **WMS:** /thredds/wms/fmrc/NCEP/GFS/Global_0p5deg/NCEP-GFS-Global_0p5deg_best.ncd
4. **NetcdfSubset:** /thredds/ncss/grid/fmrc/NCEP/GFS/Global_0p5deg/NCEP-GFS-Global_0p5deg_best.ncd
5. **CdmRemote:** /thredds/cdmremote/fmrc/NCEP/GFS/Global_0p5deg/NCEP-GFS-Global_0p5deg_best.ncd

Done

Joint AAP/ICTP Workshop - July 27, 2011

YSlow WWS

THREDDS Catalogs



Catalog Services - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://motherlode.ucar.edu:8080/thredds/catalog/fmrc/NCEP/GFS/Global_0p5deg/catalog.html?da

Catalog Services

Access:

1. OPENDAP: [/thredds/dodsC/fmrc/NCEP/GFS/Global_0p5deg/NCEP-GFS-Global_0p5deg_best.ncd](#)
2. WCS: [/thredds/wcs/fmrc/NCEP/GFS/Global_0p5deg/NCEP-GFS-Global_0p5deg_best.ncd](#)
3. WMS: [/thredds/wms/fmrc/NCEP/GFS/Global_0p5deg/NCEP-GFS-Global_0p5deg_best.ncd](#)
4. NetcdfSubset: [/thredds/ncss/grid/fmrc/NCEP/GFS/Global_0p5deg/NCEP-GFS-Global_0p5deg_best.ncd](#)
5. CdmRemote: [/thredds/cdmremote/fmrc/NCEP/GFS/Global_0p5deg/NCEP-GFS-Global_0p5deg_best.ncd](#)

Creators:

- DOC/NOAA/NWS/NCEP
 - email: http://www.ncep.noaa.gov/mail_liaison.shtml
 - <http://www.ncep.noaa.gov/>
- National Oceanic and Atmospheric Administration (NOAA)/National Weather Service (NWS)
National Center for Environmental Prediction (NCEP)
 - email: http://www.ncep.noaa.gov/mail_liaison.shtml
 - <http://www.ncep.noaa.gov/>

Publishers:

- UCAR/UNIDATA
 - email: support@unidata.ucar.edu
 - <http://www.unidata.ucar.edu/>
- University Corporation for Atmospheric Research (UCAR)/Unidata
 - email: support@unidata.ucar.edu
 - <http://www.unidata.ucar.edu/>

TimeCoverage:

- Start: 2010-09-19 00:24:19Z
- End: 2010-11-03 00:24:19Z
- Duration: 45 days

Viewers:

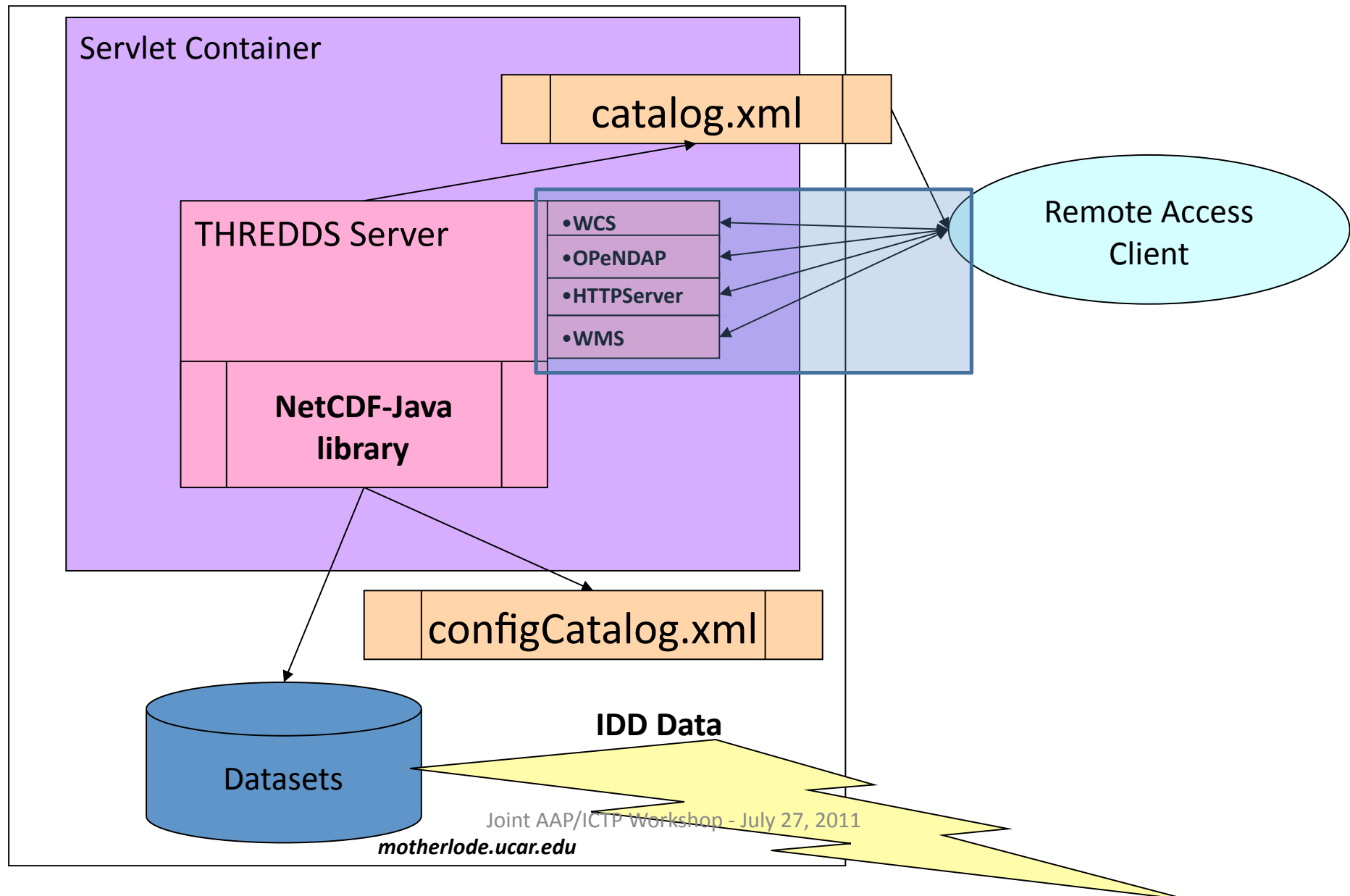
- Integrated Data Viewer (IDV) (webstart)
- NetCDF-Java ToolsUI (webstart)
- Godiva2 (browser-based)

Done

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YSlow S WMS

THREDDS Data Server



Data Access Services

- Bulk File Transfer
 - HTTP Server (any file)
- Remote access, subsetting CDM files
 - OPeNDAP (any* CDM file)
 - Web Coverage Service (grids)
 - Web Map Service (grids)
 - Others
 - NetCDF Subset Service (grids)
 - Radar Collection Subset Service
 - CDM Remote Service

Data Access Services Clients

- OPeNDAP ([lots](#), including IDV, NCL, IDL, MatLAB)
- WCS (still minimal, but expect to grow)
 - GDAL, CADCorp, George Mason, OWSLib
- WMS (speak WMS; consume GIF, JPEG, and PNG)
 - Browsers, Portals, ARC GIS, Google Earth, IDV, [etc](#)
- NetCDF Subsetter
 - HTML forms interface
 - Web service (CUAHSI)
 - IDV, ESRI ArcGIS (manual download of netcdf-CF)

OPeNDAP Service

- Protocol for remote, subset access to CDM files
- Current version 2.0; NASA ESE standard
 - Working on new 4.0 protocol spec
- TDS can serve any* CDM file
 - Subsetting by variable, index range

OGC Web Services

- OGC (Open Geospatial Consortium)
- Web Services:
 - Web Feature Service (vector, GIS, GML)
 - Web Map Service (raster, GIS, 2D, jpeg)
 - Web Coverage Service (4D, data formats)
 - Web Processing Service Remote GIS operations
 - Web Catalog Service (CSW) (SQL-like query service)
- Based on ISO/TC 211 Family of Standards
 - ISO/TC 211 = Geographic Information/Geomatics
- Google donated KML spec to OGC
- Motivated by a huge drive towards standardization
- Standards still evolving

OGC Web Coverage Service (WCS)

- TDS supports WCS 1.0
- Can subset the dataset by:
 - Lat/lon or projection bounding box
 - time and vertical coordinate range
 - list of Variables
- Return formats
 - GeoTIFF floating point, grayscale
 - NetCDF/CF-1.0
- No reprojections, resamplings
- Restricted to Gridded Datasets the CDM recognizes
 - Additional WCS restriction:
 - Grid must be evenly spaced in x,y

Web Map Service (WMS)

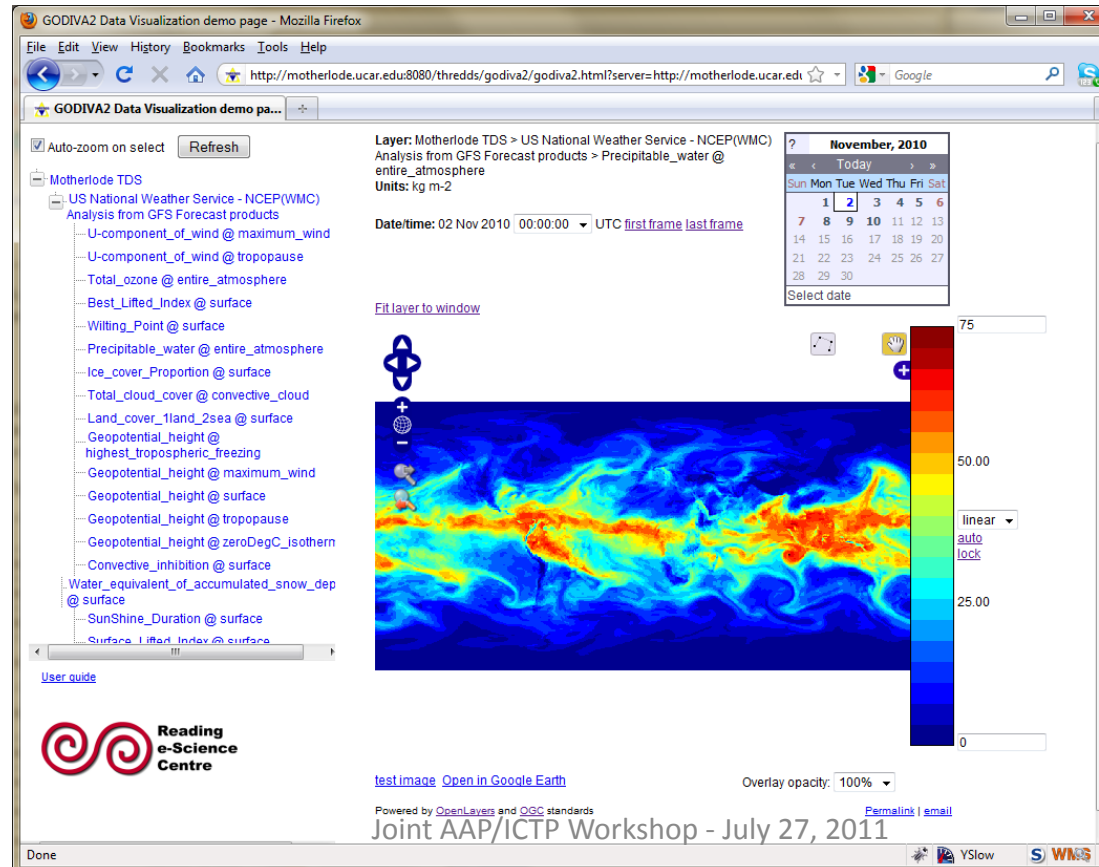
- **GetCapabilities** -> metadata
- **GetMap** -> map image, based on client-selected parameters, inc:
 - Image width/height
 - Image coordinate reference system
 - Geographic bounding box
 - Depth/height and time
 - Style
- **GetFeatureInfo** -> information about a particular map pixel
 - Format not standardized
- Specification supports 4D data (although tools often do not)

OGC Web Map Service (WMS)

- TDS WMS:
 - Based on ncWMS (Jon Blower, U of Reading)
 - Supports 1.3.0 and 1.1.1
- ncWMS notable features
 - Fast generation of images
 - Ability to read CDM datasets on variety of projections
 - Can reproject images into large number of coordinate systems
 - Uses geotoolkit's extensive projection library
- WMS specification supports 4D data (tools often do not)

TDS WMS (cont)

- Godiva2 web client (ncWMS)
 - Uses OpenLayers (JavaScript) library



WMS Interoperability

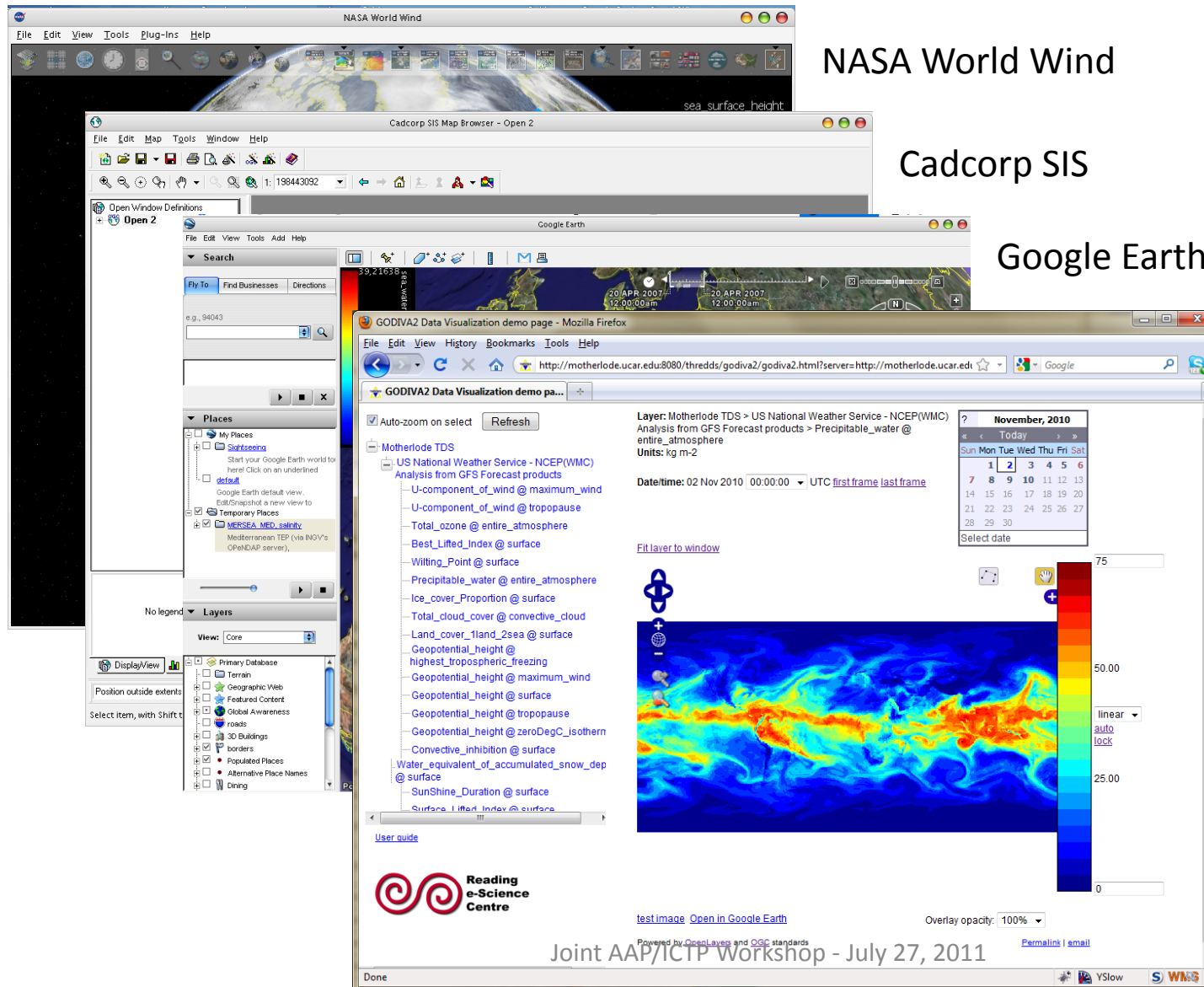
3rd-party clients can't use the custom WMS extensions

NASA World Wind

Cadcorp SIS

Google Earth

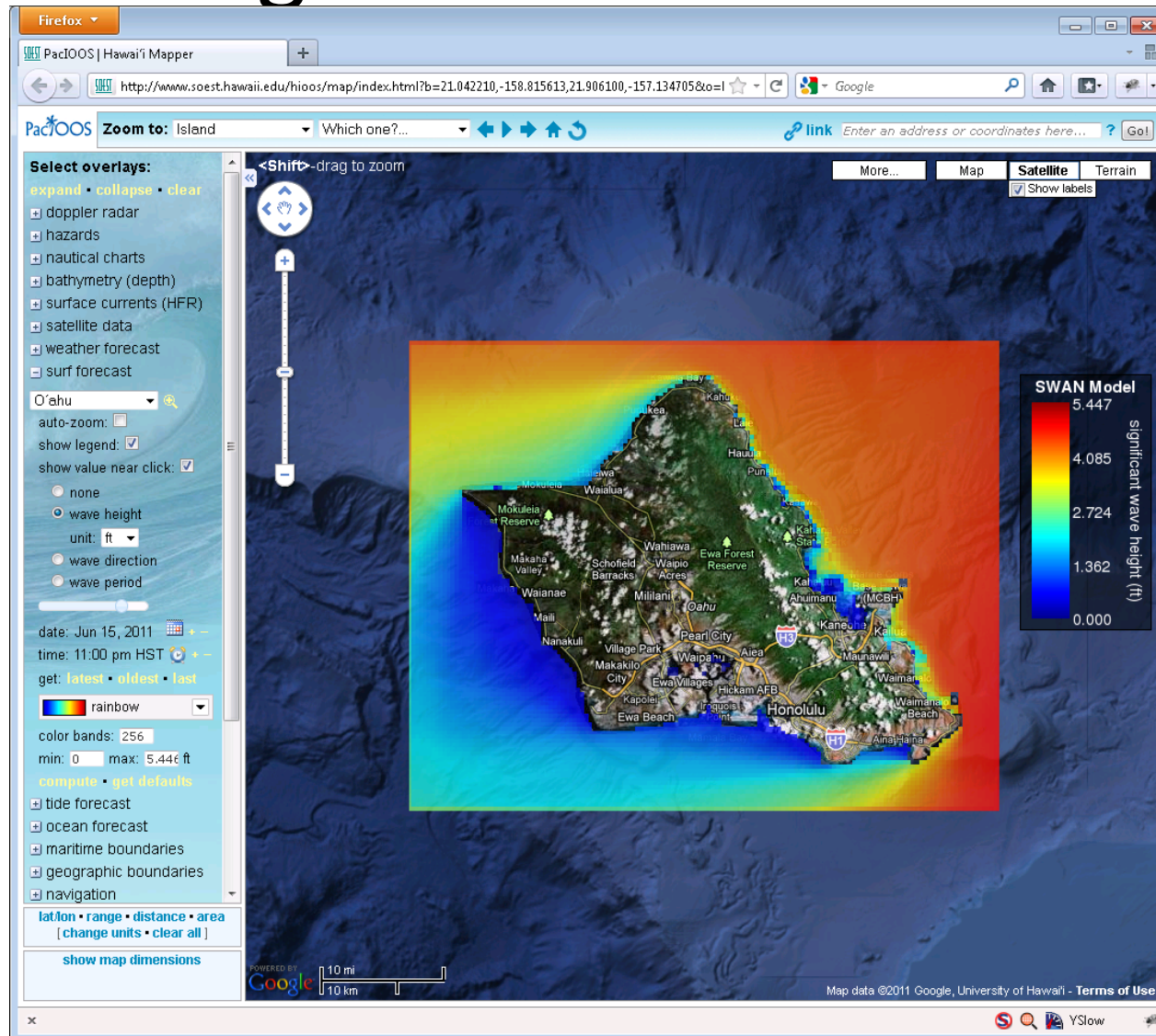
Godiva 2



NetCDF Subset Service

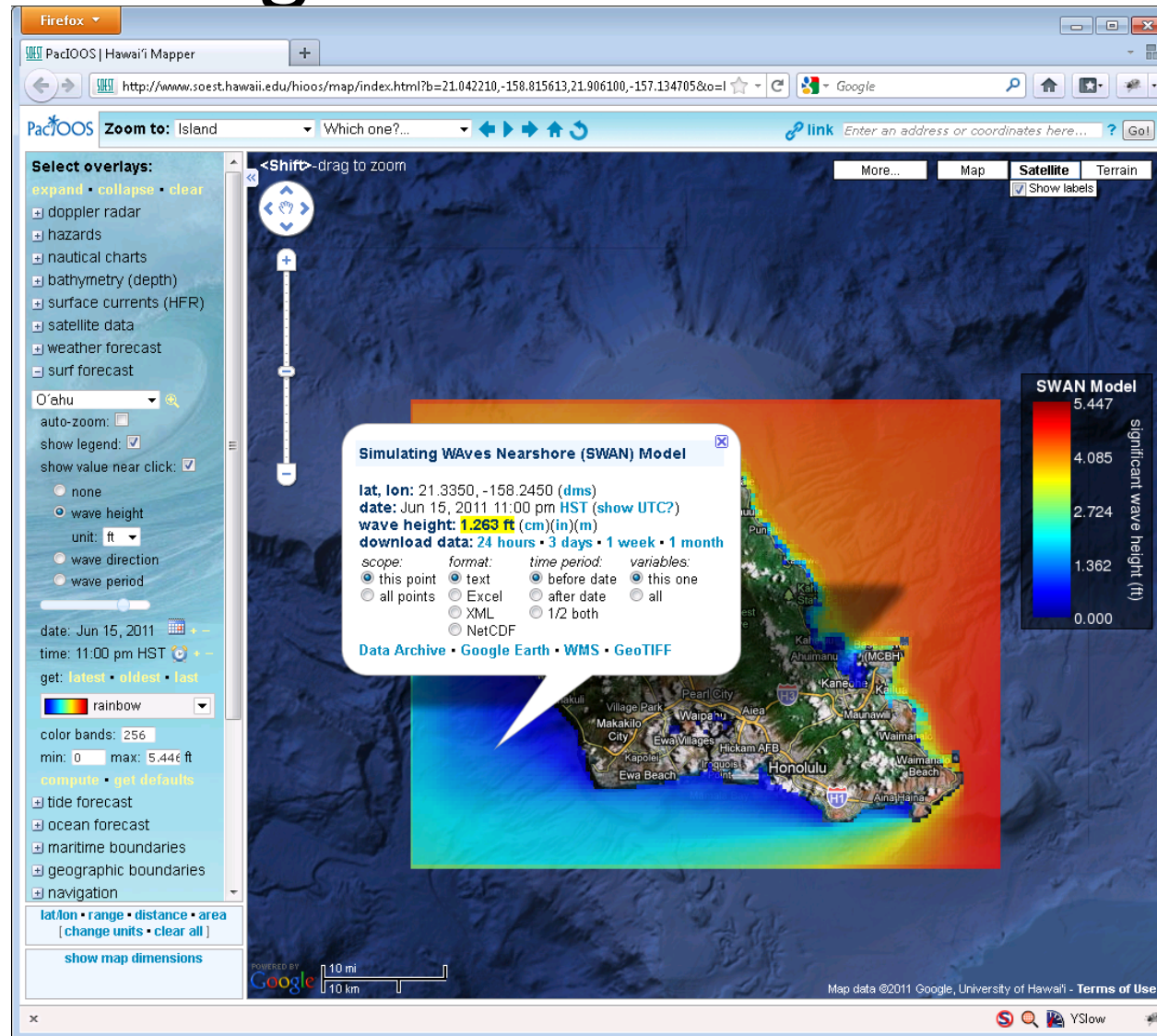
- Experiment with REST style web service
- Allow to subset the dataset by:
 - Lat/lon bounding box
 - time and vertical coordinate range
 - list of Variables
- Output: NetCDF, XML, CSV (spreadsheet)
- Gridded Data
 - Output is a CF / netCDF file
 - Variation of WCS (simplified request protocol)
- Grid as Point Datasets
 - Extract vertical profile, time series from one point in model data
 - Station Data: metars (7 day rolling archive)

Using WMS and NCSS



* From PacIOOS site, developed by John Maurer, U of HI

Using WMS and NCSS

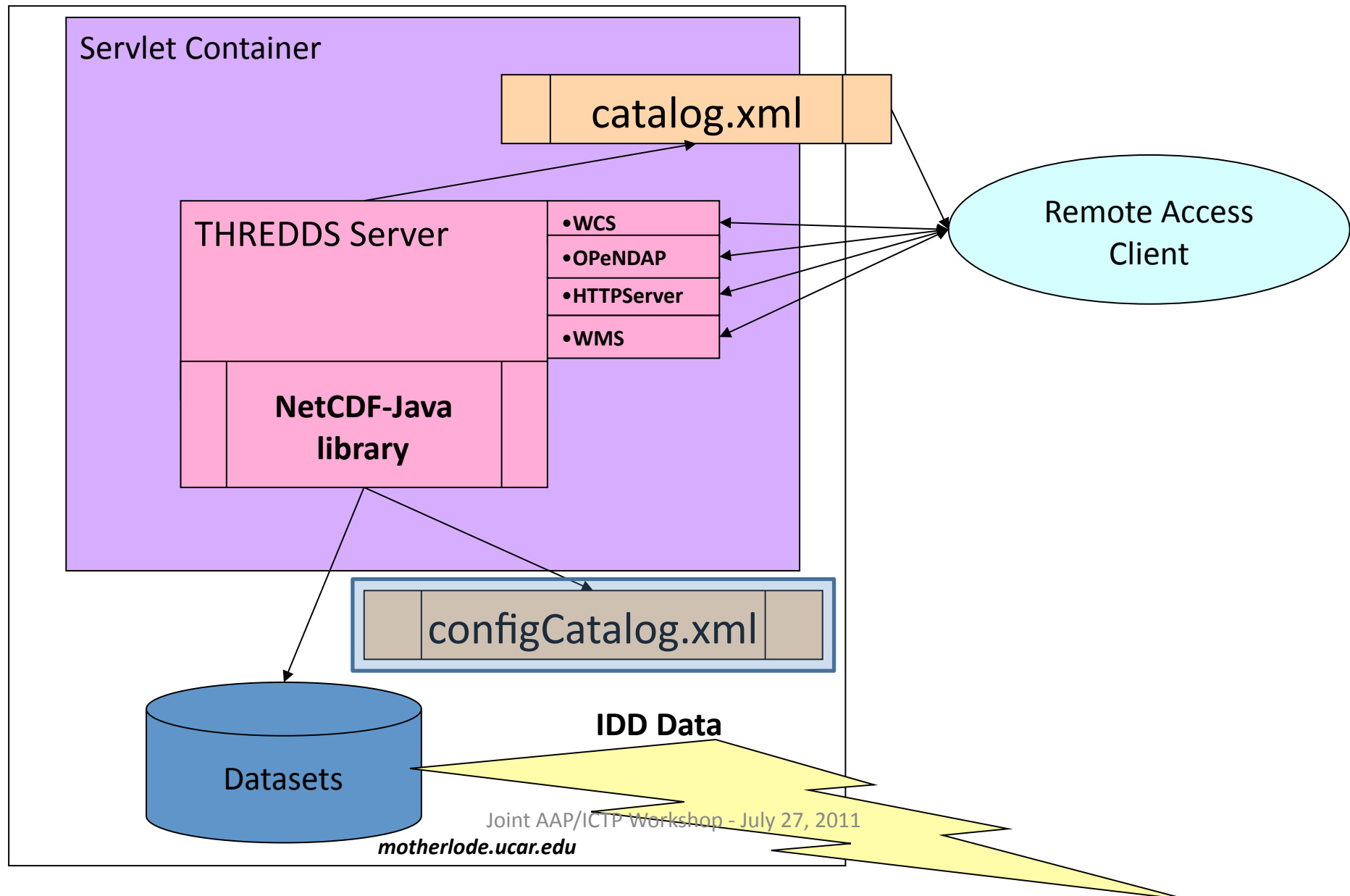


* From PacIOOS site, developed by John Maurer, U of HI

ncISO

- Developed by NOAA/NGDC
- Supports three metadata services
 - Provides an NcML representation of a dataset
 - Provides an ISO 19115-2 metadata representation of a dataset
 - Provides an evaluation of how well the metadata contained in the dataset conforms to the [NetCDF Attribute Convention for Data Discovery \(NACDD\)](#)
- Harvesting tools: GI-Cat

THREDDS Data Server



Configuration Catalogs

- Administrator tells the TDS which / how datasets are to be served
- Identify the files on disk
- Name, organize, sort, filter into virtual collections
- Add discovery metadata
- Integrated with NcML
 - Create virtual datasets

TDS Configuration Catalogs

```
...  
<datasetScan name="Ocean Satellite Data"  
    path="/data/ocean/sat/"  
    location= "/data/tds/netcdf/">  
  
    <metadata inherited="true">  
        <serviceName>odap</serviceName>  
        <dataType>Grid</dataType>  
        <dataFormat>NetCDF</dataFormat>  
        <documentation xlink:href="http://ncep.noaa.gov/modelinfo/index.html"  
            xlink:title="NCEP Model documentation" />  
        <documentation type="processing_level">  
            Transmitted through Unidata Internet Data Distribution.  
        </documentation>  
    </metadata>  
</datasetScan>  
...
```

TDS and NcML

- NcML: an XML representation of netCDF.
 - Can “fix” metadata problems
 - Can augment metadata
 - Can aggregate datasets
 - General Aggregations: joinNew, joinExisting, Union
 - Specialized aggregations:
 - Forecast Model Run Collection (FMRC)
 - Point Feature Collections
- Embed NcML into the TDS configuration catalog
- Server serves a *virtual dataset* defined by NcML
 - NcML hidden from the client

TDS / NcML

Modify and serve through TDS

```
<dataset name="Polar Orbiter Data" urlPath = "idd/sat/PolarData" >  
  
  <netcdf location="/data/sat/P02393.hdf">  
    <attribute name="Conventions" value="CF-1.4"/>  
    <variable name="Reflectivity" orgName="R34768">  
      <attribute name="units" value="dBZ" />  
      <attribute name="coordinates" value="time lat lon" />  
    </variable>  
  </netcdf>  
  
</dataset>
```

TDS / NcML

Modify all files in datasetScan

```
<datasetScan name="Polar Orbiter" path="/data/sat/"
  location= "/data/hdf/polar/">

  <netcdf>
    <attribute name="Conventions" value="CF-1.4"/>
    <variable name="Reflectivity" orgName="R34768">
      <attribute name="units" value="dBZ" />
      <attribute name="coordinates" value="time lat lon" />
    </variable>
  </netcdf>
</datasetScan>
```

TDS / NcML Aggregation

```
<dataset name="WEST-CONUS_4km Aggregation"  
  urlPath="satellite/3.9/WEST-CONUS_4km">  
  
  <netcdf>  
    <aggregation dimName="time" type="joinExisting">  
      <scan location="/data/satellite/WEST-CONUS_4km/" suffix=".gini" />  
    </aggregation>  
  </netcdf>  
  
</dataset>
```

TDS FMRC Aggregation

```
...  
<featureCollection name="NCEP-NAM-Polar_90km" featureType="FMRC"  
    path="fmrc/NCEP/NAM/Polar_90km">  
  <collection spec="/data/NAM_Polar_90km_#yyyyMMdd_HHmm#.grib2$"   
    recheckAfter="15 min" olderThan="5 min"/>  
  <update startup="true" rescan="0 5 3 * * ? *" />  
  <protoDataset choice="Penultimate" change="0 2 3 * * ? *" />  
  <fmrcConfig regularize="true" datasetTypes="TwoD Best Files Runs" />  
</featureCollection>  
...
```


For More Information

- TDS Home page
 - <http://www.unidata.ucar.edu/projects/THREDDDS/tech/TDS.html>
- TDS Workshop/Tutorial
 - <http://www.unidata.ucar.edu/projects/THREDDDS/tech/tds4.2/tutorial/>
- Unidata THREDDDS Server (motherlode)
 - <http://motherlode.ucar.edu/thredds>